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THESIS

THE GRADUATE RECORD EXAMINATION (GRE)
AS A PREDICTOR
OF SUCCESS AT THE NAVAL POSTGRADUATE
SCHOOL

by

Barbara T. Transki

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Thesis Advisor Roger D. Evered

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The Naval Postgraduate School is conducting a three-year study to determine whether or not to use the Graduate Record Examination as a selection tool admissions standard. Students are currently selected based on their professional military performance and their undergraduate grades, math and science exposure. This thesis examines a sample of 198 students who took the Graduate Record Examination after arrival at the school and who have completed six quarters of study. The results indicate that the Graduate Record Examination is a much stronger predictor than the currently used undergraduate measures (Academic Profile Code). When the Graduate Record Examination scores are combined with undergraduate grade point average and the officer's age, an excellent predictor is developed. The thesis contains, in addition to descriptive information and regression results, a prediction equation which may be used by Navy selection committees in determining whether or not an officer will succeed at the Naval Postgraduate School. Theses. (Scan)

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The Graduate Record Examination (GRE) as a Predictor
of Success at the Naval Postgraduate School

by

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ABSTRACT

The Naval Postgraduate School is conducting a three-year study to determine whether or not to use the Graduate Record Examination as a selection tool/admissions standard. Students are currently selected based on their professional military performance and their undergraduate grades, math and science exposure. This thesis examines a sample of 198 students who took the Graduate Record Examination after arrival at the school and who have completed six quarters of study. The results indicate that the Graduate Record Examination is a much stronger predictor than the currently used undergraduate measures (Academic Profile Code). When the Graduate Record Examination scores are combined with undergraduate grade point average and the officer's age, an excellent predictor is developed. The thesis contains, in addition to descriptive information and regression results, a prediction equation which may be used by Navy selection committees in determining whether or not an officer will succeed at the Naval Postgraduate School.

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I. INTRODUCTION

> [The Navy] requires officers capable of original thought and the capacity to synthesize broad areas of knowledge, analyze complex issues, and appreciate the distinction between what is theoretically possible and actually achievable. Investment in graduate education must be pursued as a priority, even in the face of fiscal austerity and competing demands for our junior officers.
>
> Admiral Carlisle H. Trost
> [Ref. 1: p. 4]

To carry out this Chief of Naval Operations Policy, the Navy must select those officers for graduate education who will succeed in their academic endeavor and benefit the service. Most officers selected attend the Naval Postgraduate School in Monterey, California. There they study a variety of technical, scientific and management curricula.

A. ADMISSION STANDARDS

The Naval Postgraduate School, as all other graduate schools, seeks to enroll those students who have the best chance for success in their academic endeavor and their related professional careers. It is impossible to accurately predict the future, but measures are available for assessing academic potential. Among these are the Graduate Record Examination (GRE), the Graduate Management Admission Test (GMAT), undergraduate grade point averages, personal recommendations and resumes of extracurricular and community activities.

The Chief of Naval Operations' policy is that graduate education be afforded those officers "who have demonstrated superior professional performance and the intellectual capability to complete a rigorous academic program." [Ref. 1: p. 4] The Navy, therefore, assesses a prospective student's academic potential through professional military performance, potential for further promotion and the Academic Profile Code. The Academic Profile Code is actually a combination of assessments: undergraduate grade point average and undergraduate exposure to math and science.

The Navy is interested in the best match between individuals and education programs it can achieve. This is particularly true when it comes to graduate education for its officers. A great deal is invested in the Naval Postgraduate School and the officers who attend. Beyond the obvious costs of maintaining an institution on a par with prestigious civilian graduate schools, there are opportunity costs to the Navy in having officers attending school instead of performing their military missions in the fleet.

The question is: Do the Navy's current admission criteria provide the best match between individual and curricular program?

B. BACKGROUND

The 1984 Graduate Education Review Board met in October of that year to plan resolution of issues discussed at the meeting of the Graduate Education Review Group two days earlier. One issue of interest was graduate education selection and admission criteria.

The Vice Chief of Naval Operations, in January 1985, requested "NPS OP-01 explore the use of indices to measure the quality and potential of entering graduate students." [Ref. 2] He further suggested that "national norms such as the Graduate Record Examinations should be considered [as] these factors could ultimately provide useful broad-based correlations on subsequent student academic performance and provide useful quality control data." [Ref. 2]

In response to this tasking, the Superintendent of the Naval Postgraduate School identified three deficiencies of the Academic Profile Code:

1. Differences in institution standards cannot be measured.
2. There is an engineering bias.
3. Written and verbal skills are not quantified. [Ref. 3]

He further recommended the Graduate Record Examination be required of all officers during college or during officer training. His recommendation discussed the benefits of the Graduate Record Examination: uniformity and data for correlation analysis regarding admission criteria and success in graduate school.

Another exchange of letters followed this initial round and culminated in June of 1985 with approval of a three-year study of the Graduate Record Examination. This letter indicated that all officers ordered to the graduate program from April 1986 until April 1989 would be required to take the Graduate Record Examination before arrival at the school. The scores would be reported to Commander, Naval Military Personnel Command for inclusion in the officer master file. This would allow Naval Postgraduate School to collect data for analysis. [Ref. 4]

A final correspondence exchange authorized administration of the Graduate Record Examination within the first two weeks of students' arrival at the Naval Postgraduate School. That is the form of the study which is currently underway. All U.S. Navy officers take the Graduate Record Examination within the first few weeks of arrival at the

school. Scores are subsequently reported to Commander, Naval Military Personnel Command and to the Naval Postgraduate School.

C. RESEARCH QUESTIONS

The questions addressed in this thesis are:

1. Which criteria predict academic performance at the Naval Postgraduate School better: Academic Profile Code scores or Graduate Record Examination scores?
2. Is there a difference in the predictive value for different curricula?
3. How do the Naval Postgraduate School students compare with other graduate students at other institutions?

II. LITERATURE REVIEW

Not much research has been done at the Naval Postgraduate School regarding alternate admission or selection criteria. Most efforts were class projects, staff speculations or studies directed toward a specific curriculum. There was apparently an effort to institute the Graduate Record Examination as a selection variable in the 1960s. A series of three theses was written during that time discussing the Graduate Record Examination as well as other predictive instruments. All three, though focusing on the management curriculum, bear mention. Other studies conducted in the 1970s and 1980s are also of interest to this thesis.

A. 1960'S

1. Martz/Rushin

In 1962, Martz and Rushin produced the first of this series of theses examining the use of the Graduate Record Examination in the management curriculum. They considered the Graduate Record Examination, the California Analogies and Reasoning Test and the Navy Officer Classification Battery. After performing a number of statistical tests on data collected from the 1962 class (N = 94), they determined the Graduate Record Examination was the most statistically significant of the instruments examined. Their recommendation to use the Graduate Record Examination was couched in hesitant terms, however. Specifically, "the Graduate Record Examination (aptitude) produced by the Educational Testing Service was found to be the best of the three instruments considered but is encumbered with certain restrictions that reduce the adaptability for Navy-wide testing as proposed in this study. The Graduate Record Examination is recommended as a highly effective tool for faculty-student counselling and guidance programs." [Ref. 5: p. i]

2. Kauder/Ebert

The second in the Management School theses series was written in 1963 by Kauder and Ebert. They studied the Navy Officer Classification Battery, the Graduate Record Examination and the Navy Officer Qualification Test. Statistical analysis was conducted on the class of 1963 (N = 94) with a statistical reliability of 95 percent. Kauder and Ebert concluded that the Graduate Record Examination had a very high validity and was, in fact, the best predictor of the three options. Based upon this

conclusion, they recommended the Graduate Record Examination be used as the admission criterion. [Ref. 6]

3. Dreese/Russel

Finally, in 1964, Dreese and Russel examined the Graduate Record Examination, the Structured-Objective Rorschach Test-Sort, the Allport-Vernon-Lindzey Study of Values and a local questionnaire of motivation. They studied the management class of 1964 (N = 99). After extensive statistical correlation, they concluded that the Graduate Record Examination was an "excellent predictor of academic performance" [Ref. 7: p. 29] and should be administered to management candidates. [Ref. 7]

B. 1970'S

1. Cook

Worthy of mention is a thesis conducted in 1974 by Cook. This paper is concerned with the merits of the Graduate Record Examination, the Strong Vocational Interest Blank, a biographical questionnaire and undergraduate academic performance in determining success in the Communications Management curriculum (N = 42). This thesis, unlike the previous studies, considered not only psychological and testing instruments, but also the Educational Potential Code. The Educational Potential Code was an earlier version of today's Academic Profile Code. His conclusion did not specify which of these instruments was best, but instead built a series of tables with combinations of indicators to assist in student selection. [Ref. 8]

2. Elster

In August of 1974, Professor R. S. Elster prepared a letter to the Naval Personnel Research and Development Center offering a manual to be used by the graduate education selection boards. It contained prediction tables for four curricula. These tables were based on such factors as undergraduate grades, undergraduate university "school scores," age, foreign language ability, whether or not the officer was a Naval Academy graduate, rank, Graduate Record Examination scores and whether or not the officer had an engineering degree. The tables were to be used after the selection boards had considered professional military performance and undergraduate academic performance. [Ref. 9]

C. 1980'S

1. Michealson/Phillips/Jeong/Lee

In a 1985 class project, Michealson, Phillips, Jeong and Lee attempted specifically to look at correlations between final grades and the Academic Profile Code, as well

as final grades and undergraduate grade point averages. They studied the December 1984 graduating class (N = 52). They found the highest correlations among those students who were Naval Academy graduates and those students who were in technical curricula. One would expect this result since the Academic Profile Code measures not only the undergraduate grade point average, but also exposure to technical curricula. [Ref. 10]

2. Blatt

Blatt used an analysis of variance technique to look at students in the Operations Analysis curriculum (N = 159). He was interested in student performance as measured by the Academic Profile Code, time since undergraduate studies, which undergraduate college the student attended, what kind of degree the student earned, what the student's military desginator was and whether or not the student had attended the math refresher training before starting the Operations Analysis courses. He found the undergraduate grade point average score of the Academic Profile Code to be a significant variable. The math and science codes of the Academic Profile Code, however, were not meaningful. Other factors he found to be significant were the time away from undergraduate studies, military designator and type of college degree. [Ref. 11]

3. Barr/Howard

Perhaps the most definitive and useful study done to date was accomplished by Barr and Howard in 1987. They took a preliminary look at data collected from the three-year study begun in April 1986. Their report encompassed 320 records of students who had taken the Graduate Record Examination and had completed at least three quarters of study at the Naval Postgraduate School.

Their conclusions were five-fold:

1. Using the Graduate Record Examination in conjunction with the other currently used admission criteria will significantly improve the prediction.
2. The best selection of variables is the verbal and quantitative scores of the Graduate Record Examination used with the undergraduate grade point average score of the Academic Profile Code and the student's age.
3. The math and science scores of the Academic Profile Code are not significantly useful in prediction. They are, however, still an important part of the admission criteria.
4. Predictor significance varies over curricula.
5. Distinguishing poor performers is difficult using the variables available. [Ref. 12]

III. ASSUMPTIONS AND METHODOLOGY

The primary issue of this thesis is whether or not the Graduate Record Examination is a good predictor of success at the Naval Postgraduate School. What is success? How is it measured? This chapter will attempt to define success, the indices used to measure it and the methodology used to determine the applicability and strengths of those measures.

A. "SUCCESS" AT THE NAVAL POSTGRADUATE SCHOOL

How does one define success as related to academic performance? Grades, student involvement in campus affairs, the degree, quality of the thesis; all could be considered indicators of success. Hartnett and Willingham discuss how criteria for success are widely defined among schools, school departments, and even curricula within departments. They offer three categories of criteria.

1. Categories

The first category is "administrative measures" such as grades, exams, the thesis and status of the degree. Second, "professional accomplishments" such as recognition through awards or other honors, publications, professional activities and experience. And last, specially developed "objective criteria" of the sort than can be measured such as work samples, common examinations or ratings of competencies and characteristics. [Ref. 13: p. 10]

The remainder of their study discusses merits and weaknesses of each of the criteria mentioned. Of particular interest to this study is their discussion of grades as a measure of success.

2. Grades

a. Advantages

On a positive note, Hartnett and Willingham suggest that grades are an indication of the faculty's view of academic progress. They are readily available for all students in a scale easily interpreted by most. They also appear to be a composite indicator of variations in academic performance in a variety of courses. [Ref. 13: pp. 11-12]

b. Disadvantages

There are a number of disadvantages in using grades as a predictor. Grades generally are of a very restricted range and do not reflect the potentially wide range of differences in student accomplishment. Standards are extremely variable over time,

institutions, departments and curricula. The basis of the grades is not always clear: exams, papers, research and class participation are all possibilities. [Ref. 13: pp. 12-13]

They conclude "that while grades serve several useful functions in graduate education, the one served least well is that of providing an understandable criterion of graduate student performance." [Ref. 13: p. 14] They acknowledge that grades are part of the evaluation process and should be used judiciously.

3. Quality Point Rating as the Preferred Measure of Success

Taking the above cautions under consideration, this study will use grade average as the criterion against which to measure success in graduate school. The Naval Postgraduate School term for grade average is "Quality Point Rating."

The Quality Point Rating is a weighted average of grades computed using the grade values depicted in Table 1.

Table 1. QUALITY POINT RATING COMPUTATION

Grade	Points
A	4.0
A-	3.7
B+	3.3
B	3.0
B-	2.7
C+	2.3
C	2.0
C-	1.7
D+	1.3
D	1.0
X	0.0

Source: Admissions Office Handout

The values in Table 1 are multiplied by the number of quarter-hour credits for each course. All course quality points are then summed and subsequently divided by the total number of credit hours. The resulting number is the Quality Point Rating. The Quality Point Rating is calculated separately for total performance in all courses and for graduate-level courses. [Ref. 14: pp. 20-21]

The Naval Postgraduate School defines success in graduate education as being eligible for the Master's Degree by attaining "a minimum average Quality Point Rating of 3.00 in all the 3000 and 4000 level [graduate] courses in [the] curriculum, and 2.5 in the remaining courses or a 2.75 in all courses of the curriculum." [Ref. 14: p. 21]

B. ADMISSION CRITERIA

1. Academic Profile Code

The Academic Profile Code is currently used in conjunction with professional military performance as the most important admission criterion. It is composed of three digits reflecting the student's undergraduate experiences.

a. Undergraduate Quality Point Rating Code

This first digit of the Academic Profile Code describes the officer's Undergraduate Quality Point Rating. Table 2 displays the code, grades and Undergraduate Quality Point Rating range.

Table 2. UNDERGRADUATE QUALITY POINT RATING CODE

Code	Grade	UQPR Range
0	A- A	3.60-4.00
1	B+	3.20-3.59
2	B- B	2.60-3.19
3	C+	2.20-2.59
4	C	1.90-2.19
5	Below C	0.00-1.89

Source: Admissions Office Handout

Codes 0 through 3 must be based on a minimum of 100 semester or 150 quarter hours of graded courses. Pass fail, credit examinations and similar credits are not considered.

b. Undergraduate Math Code

The second digit of the Academic Profile Code indicates the officer's undergraduate exposure to math. A description of the codes follows in Table 3 on page 10.

Table 3. UNDERGRADUATE MATH CODE

Code	Calculus-Related Math Courses
0	Significant post-calculus math with a B average
1	Two or more calculus courses with a B+ average
2	Two or more calculus courses with a C+ average
3	One calculus course with a C grade or better
4	Two or more pre-calculus courses with a B average or better
5	At least one pre-calculus course with a C grade or better
6	No college-level pre-calculus course with a C grade or better

Source: Admissions Office Handout

c. Undergraduate Technical Code

The final digit of the Academic Profile Code reflects undergraduate experience in physics or engineering. The codes are interpreted in Table 4.

Table 4. UNDERGRADUATE TECHNICAL CODE

Code	Courses
0	Significant upper-division course coverage in a pertinent engineering or physical science discipline with a B+ average
1	Significant upper-division course coverage in a pertinent engineering or physical science discipline with a C+ average
2	Complete calculus-based physics sequence with a B+ average
3	Complete calculus-based physics sequence with a C+ average
4	At least on calculus-based physics course with a C grade
5	None

Source: Admissions Office Handout

2. Graduate Record Examination

The Graduate Record Examination has been in use in one form or another since the late 1930s. This standardized paper and pencil test was first administered as a battery of eight exams measuring math, physics, chemistry, biology, social studies, literature, fine arts and verbal skills. Advanced tests (known today as subject exams) were also developed to measure skill in very specific areas of study. [Ref. 15: p. 2]

The exams have been revised constantly over the years and the number of students taking the exam has increased as well. The format of the examinations administered during the Naval Postgraduate School study has been in use since 1981. It was during that year Educational Testing Service conducted a major revision of the General Test, particularly of the analytical measure. Until 1981, Educational Testing Service had cautioned against using the analytical measure for admission decisions. These cautions have since been removed. [Ref. 16: p. 7]

a. The Exam

The General Test, which is being administered during the Naval Postgraduate School study, consists of three measures of "developed ability." [Ref. 16: p. 6] Questions using antonyms, analogies, sentence completions and reading comprehension make up the verbal measure. Quantitative skills are examined through use of discrete quantitative questions, data interpretation and quantitative comparisons. Finally, the analytical section of the exam tests analytical reasoning and logical reasoning. [Ref. 16: p. 7]

b. Scores

Scores on these three measures are the total number of questions an examinee answered correctly in each section (the raw score) equated with previous editions of the exams. This process allows the scaled scores reported to Naval Postgraduate School to be compared over time with scaled scores of other students taking older exams. The only exception to this is that analytical scores after 1981 are not comparable to those before the 1981 revision. [Ref. 16: p. 31]

c. Percentiles

The percentile ranks reported along with the scaled scores are not interpretable over time. These rankings are made for a specific group of test takers. Educational Testing Service provides a table of percentile ranks which can be used to interpret rankings of test scores earned before 1986-87. [Ref. 16: p. 31]

d. Guidelines

Educational Testing Service provides guidelines to administrators for the use of the Graduate Record Examination scores. They suggest that the Graduate Record Examination has two limitations: 1) it cannot measure *all* qualities which make up an individual and contribute to academic success and 2) "only score differences of certain magnitudes are reliable indicators of real differences in performance." [Ref. 16: p. 14] Throughout the *Guide* Educational Testing Service cautions against using the Graduate Record Examination Scores as the *only* criterion for admission or selection. There are many factors besides test scores which should be considered. They also caution against using a minimum (cut-off) score philosophy for the same reason. [Ref. 16]

e. The Graduate Record Examination as an Admissions Standard

A number of papers have been written discussing the Graduate Record Examination used as an admissions standard. Oltman and Hartnett indicated that about 64 percent of the graduate programs either require or recommend Graduate Record Examination scores. They also surveyed administrators to find out how the Graduate Record Examination scores were used. Most respondents who use the exam scores in their admission process do so to supplement other, perhaps less satisfactory academic credentials. Undergraduate grades were consistently rated as the most important admissions factor. [Ref. 17]

f. The Graduate Record Examination as a Grade Predictor

There has also been some concern about the validity of the Graduate Record Examination as a predictor of graduate grades. Wilson provides a good discussion of the subject based on the results of "The GRE Cooperative Validity Studies Project" conducted by Educational Testing Service in the latter half of the 1970s. The biggest concerns in past studies were: 1) most of the samples were quite small, making results unreliable and 2) various institutions had different ideas about what "success" in graduate school actually was. Wilson reports, however, that throughout the Validity Studies, grade point average was the common factor and was usually positive. He also stated that the Graduate Record Examination was generally a better predictor of graduate grades than other factors studied. [Ref. 18]

C. METHODOLOGY

Statistical procedures in this thesis will focus primarily on exploring correlations between the Graduate Record Examination and Academic Profile Code indices and the

Graduate Quality Point Rating. The goal is to determine which measures are most strongly and significantly correlated with Graduate Quality Point Ratings.

Additionally, the various indices will be regressed against Graduate Quality Point Rating. The resulting equation can be used by graduate education selection boards as a predictor of academic success.

The statistical package which will be used for this analysis is *SPSS*[x] . *SPSS*[x] is a trademark of SPSS, Incorporated.

IV. DATA

The data analyzed were available in the Naval Postgraduate School Admissions and Registrar offices. A data set was entered manually from Graduate Record Examination score cards received at the Naval Postgraduate School from Educational Testing Service. Data included on these cards were social security number, date of birth, date of exam and the three Graduate Record Examination scores with their respective percentiles. This file was merged with four separate registrar files containing Academic Profile Code, curriculum, designator, rank, undergraduate information and grades earned at the Naval Postgraduate School. To protect the privacy of individual students, names were not included in any of the data.

These data included only U.S. Navy students. The study has excluded other U.S. service students as well as international students.

To make the data more useful, several computations were performed. Age at time of examination was computed by subtracting date of birth from the date of the exam. Time away from undergraduate studies was computed by subtracting date of undergraduate degree from date of exam.

Since grading varies somewhat from department to department, cumulative Graduate Quality Point Ratings were standardized to make them a better comparison measure. Standardizing allows for variations in department grading practices. The standardized scores were computed by dividing students' Graduate Quality Point Rating by a department factor. The individual department factors were derived by dividing the department averages by the overall school average Quality Point Rating of 3.45 (which has remained relatively stable over several academic years) [Ref. 19]. Although the averages used were derived from all courses, not just 3000- and 4000-level courses, the numerical paucity of lower-division courses presents little effect on the factors computed. The resulting department factors are presented in Table 5 on page 15.

The merged file contained 786 cases. Six of the original Graduate Record Examination cases could not be matched with registrar files and were removed. The remaining 780 cases provide some interesting descriptive information about the U.S. Navy student population over the first 18 months of the study.

Table 5. DEPARTMENT STANDARDIZING FACTORS

Code	Department	Factor
52	Computer Science	1.029
53	Mathematics	1.009
54	Administrative Sciences	.980
55	Operations Research	.994
56	National Security Affairs (relatively easy grading)	1.067
61	Physics (relatively tough grading)	.951
62	Electrical & Computer Engineering	.986
63	Meteorology	1.000
67	Aeronautics	1.017
68	Oceanography	1.006
69	Mechanical Engineering	1.006
71	Antisubmarine Warfare Academic Group	1.000
72	Electronic Warfare Academic Group	1.044
73	Space Systems Academic Group	1.044
74	Command, Control & Communications Academic Group	1.052
	NPS--All Departments	1.000

Since the study began in April 1986, there have been seven administrations of the Graduate Record Examination for which data were available. These are shown, along with number of participating students in Table 6.

Table 6. EXAM ADMINISTRATIONS

Date of Exam	Number of Examinees
April 1986	66
August 1986	148
October 1986	133
February 1987	103
April 1987	97
July 1987	140
October 1987	93
Total	780

Students in this study are overwhelmingly male: 84.4 percent. Most students are either lieutenants or lieutenant commanders, 72.6 percent and 24.6 percent, respectively. They are 31 years old on average and have been away from undergraduate schooling an average of 7.6 years.

By military specialty, 66.7 percent are line officers (the majority being surface officers (29 percent) and the minorities being special warfare, special operations and pilots (4.5 percent collectively)). Twenty percent are restricted line and the remaining 12.9 percent are staff corps (mostly supply).

The most popular curricula (the top 60 percent, listed in decreasing order) are computer systems, naval engineering, financial management, operations analysis, weapons systems engineering, electronic systems, air-ocean sciences, computer science, space systems operations and antisubmarine warfare.

Descriptive statistics (shown in Table 7) regarding the Graduate Record Examination, Academic Profile Code and Standardized Quality Point Rating (ZQPR) scores reveal the following information:

Table 7. DESCRIPTIVE STATISTICS

Variable	Mean	Minimum	Maximum	Standard Deviation	Maximum Possible Range
UQPR Code	1.95	0	4	.88	0-5
Math Code	2.22	0	6	1.13	0-6
Technical Code	3.19	0	5	1.57	0-5
GRE-Verbal	547.95	300	800	92.41	200-800
GRE-Quantitative	632.03	370	800	93.22	200-800
GRE-Analytical	584.92	260	800	103.31	200-800
ZQPR	3.44	0.00	4.21	.38	0-4.27

Although the preceding information is very interesting and useful, there is concern about using this data for rigorous analysis. Most students have very few, if any, graduate-level courses in their first quarter or two. In most curricula the courses build in difficulty as the program progresses. Additionally, as a student progresses through

the curriculum, its many courses and varied professors, the Quality Point Rating becomes a more accurate measure of overall academic ability. It is therefore unfair to compare the Graduate Quality Point Rating of a first-quarter student with that of a sixth-quarter student. By selecting those students who have completed exactly six quarters, one captures those who have graduated from 18-month curricula as well as those who have completed the majority of long curricula. These cases should provide a better measure of academic achievement.

There is some concern among academics that there has been a steady grade creep over the years. In other words, a 25-year-old graduate student may have a higher undergraduate grade point average than a 40-year-old graduate student, yet be academically equivalent. To attempt some limited correction for this, one case in which age at time of examination was 40 or greater was eliminated.

By selecting only those records in which students had completed 6 quarters and were less than 40 years old, the data set was reduced to 198 cases. These 198 cases are described in the following tables.

Table 8 shows the breakdown by sex. Again, the vast majority of the students are men.

Table 8. SEX--SIXTH-QUARTER DATA

Sex	Percent
Male	80.8
Female	19.2

Military Specialties have been grouped into the three major categories of line, restricted line and staff corps as shown in Table 9 on page 18.

Only three rank categories are represented in this data: lieutenant junior grade (one percent), lieutenant (71.2 percent) and lieutenant commander (27.8 percent).

By limiting the data to those who have completed six quarters, the number of test administrations with usable data is limited to the five shown in Table 10 on page 18.

Table 9. MILITARY SPECIALTY--SIXTH-QUARTER DATA

Specialty	Percent	Total Percent
General Unrestricted Line	14.6	
Surface	21.7	
Subsurface	6.1	
Special Warfare/Special Operations	1.5	
Aviation	14.1	
Total Line		58.0
Total Restricted Line		22.1
Supply Corps	14.1	
Other Staff Corps	5.0	
Total Staff Corps		19.1
Total		99.2

Total column does not add to 100% due to missing cases.

Table 10. EXAM ADMINISTRATIONS--SIXTH-QUARTER DATA

Date of Exam	Number of Examinees
April 1986	11
August 1986	60
October 1986	111
February 1987	13
April 1987	3
Total	198

Table 11 on page 19 lists the curricula, showing the percentage of those 198 students enrolled in each.

Descriptive statistics were computed for this sample. Table 12 on page 20 includes the mean, minimum, maximum and standard deviation for the continuous variables.

Table 11. CURRICULUM ENROLLMENT--SIXTH-QUARTER DATA

Curriculum	Percent
Computer Systems	11.6
Financial Management	8.6
Material Logistics Support Management	7.6
Naval Engineering	6.6
Telecommunications Systems Management	6.6
Electronic Warfare	6.1
Operations Analysis	4.5
Space Systems Operations	4.5
Antisubmarine Warfare	4.0
Manpower, Personnel & Training Analysis	3.5
NSA-Nuclear Strategic Planning	3.5
Weapons Systems Engineering	3.5
Acquisition & Contract Management	3.0
Intelligence	3.0
Computer Science	2.5
Air-Ocean Sciences	2.0
Communication Engineering	2.0
Operational Logistics	2.0
Transportation Logistics Management	2.0
Aeronautical Engineering	1.5
NSA-International Organizations & Negotiations	1.5
Space Systems Engineering	1.5
Transportation Management	1.5
Underwater Acoustics	1.5
Aeronautical Engineering	1.0
Electronic Warfare	1.0
Weapons Systems Science	1.0
Command, Control & Communications	.5
NSA-Far East, Southeast Asia, Pacific	.5
NSA-Europe, USSR	.5
Systems Inventory Management	.5

Table 12. DESCRIPTIVE STATISTICS--SIXTH-QUARTER DATA

Variable	Mean	Minimum	Maximum	Standard Deviation
Age	31.05	25	39	3.47
Time Since Undergrad Degree	7.65	1	17	2.95
UQPR Code	1.89	0	4	.832
Math Code	2.41	0	6	1.25
Technical Code	3.27	0	5	1.66
GRE-Verbal	545.46	300	740	93.62
GRE-Quantitative	627.42	370	800	95.39
GRE-Analytical	588.38	300	800	99.60
Standardized Graduate QPR	3.48	2.52	4.07	.294

V. ANALYSIS

To develop an understanding of the relationship between the standardized Graduate Quality Point Rating and the various explanatory variables, it was useful to first look at simple correlations. The larger the correlation coefficient, the stronger the relationship. To further provide a better selection tool, regressions were run to estimate predictive equations.

To simplify discussion of the results, variables have been assigned the following names:

Academic Profile Code	
Undergraduate Quality Point Rating Code	APC1
Math Code	APC2
Technical Code	APC3
Graduate Record Examination	
Verbal	VB
Quantitative	QT
Analytical	AN
Other Variables	
Age at time of exam (in years)	AGE
Time since undergraduate degree (in years)	T
Standardized Graduate Quality Point Rating	ZQPR
Predicted Graduate Quality Point Rating	QPR*

A. CORRELATION

Using the SPSSx Pearson correlation function, correlation tables were constructed for the entire sixth-quarter data set as well as separately for the Policy and Information Sciences Division and the Sciences and Engineering Division.

1. Sixth-Quarter Data

Table 13 on page 22 depicts the relationship between ZQPR and three Graduate Record Examination measures, the three Academic Profile Code measures, AGE and T.

What becomes apparent in analyzing this table is that AGE and T are strongly correlated with one another and that T has a very small effect on ZQPR. Not only is the correlation a small absolute value, but it is significant only to the ten percent level. The other anomalies in this table are APC2 and APC3. Both are quite small and significant only to the ten percent level for APC2 and the five percent level for APC3. The

Table 13. CORRELATION TABLE--SIXTH-QUARTER DATA

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000 (198)	.719 (189) .000	.023 (198) .375	-.264 (198) .000	-.269 (198) .000	.042 (194) .282	.296 (194) .000	.230 (194) .001	-.244 (198) .000
T		1.000 (189)	.150 (189) .020	-.138 (189) .029	-.171 (189) .009	-.067 (185) .183	.233 (185) .001	.214 (185) .002	-.096 (189) .094
VB			1.000 (198)	.272 (198) .000	.446 (198) .000	-.245 (194) .000	-.010 (194) .445	-.042 (194) .278	.311 (198) .000
QT				1.000 (198)	.615 (198) .000	-.262 (194) .000	-.488 (194) .000	-.533 (194) .000	.424 (198) .000
AN					1.000 (198)	-.124 (194) .042	-.233 (194) .001	-.269 (194) .000	.350 (198) .000
APC1						1.000 (194)	.164 (194) .011	.090 (194) .107	-.348 (194) .000
APC2							1.000 (194)	.562 (194) .000	-.108 (194) .067
APC3								1.000 (194)	-.121 (194) .046
ZQPR									1.000 (198)

Correlation Coefficient
(Number of Cases)
One-Tailed Significance Level, p-value

remaining variables: AGE, VB, QT, AN and APC1 show reasonably strong correlations which are significant at the one percent level.

The probable explanation is that the Graduate Record Examination quantitative and analytical sections are better measures of the math and science knowledge of an individual than the Academic Profile Code measures.

The negative sign of the age factor suggests that "older" students do have slightly lower scores than their younger counterparts.

These correlation results hint that T, APC2 and APC3 do not contribute much to prediction of graduate success.

The reader must remember Table 2 on page 9, Table 3 on page 10 and Table 4 on page 10 when interpreting correlation coefficients of the Academic Profile Code measures. The *lower* the number in the code, the better. One would, therefore, *expect* negative correlations with ZQPR. The Graduate Record Examination scores, on the other hand, are "normal"--the higher the score, the better. These correlations are expected to be positive.

2. Division Data

Additionally, tables were constructed for the two major Divisions within the school. The correlation results are displayed in Table 14 on page 24 and Table 15 on page 25.

a. Policy and Information Sciences Division (05)

For the Policy and Information Sciences Division (N = 135) the table shows similar results. T is now a small and insignificant factor. QT and APC1 appear to have the strongest correlation with ZQPR. APC2 and APC3 are small and not as statistically significant as the GRE measures.

b. Sciences and Engineering Division (06)

In the Sciences and Engineering Division (N = 63) T, APC2 and APC3 are relatively small and insignificant. AGE appears to be a much bigger factor for this group. Perhaps that can be explained by the theory that quantitative skills decline as one gets older and does not use them as much. Of interest, though, is the very strong correlation between ZQPR and QT: .5940 which is statistically significant at the one percent level. As might be expected for the scientists and engineers, VB is not nearly as strong as QT and AN.

c. Conclusion

Table 16 on page 26 combines the previous three correlation tables into one. Shown are the correlations between ZQPR and the eight explanatory variables discussed.

These results confirm that the Graduate Record Examination measures along with APC1 and AGE are the most useful in predicting success at Naval Postgraduate School.

Table 14. CORRELATION TABLE--DIVISION 05

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000 (135)	.709 (129) .000	-.018 (135) .416	-.285 (135) .000	-.271 (135) .001	.070 (131) .215	.343 (131) .000	.293 (131) .000	-.178 (135) .019
T		1.000 (129)	.102 (129) .126	-.099 (129) .133	-.126 (129) .078	-.017 (125) .426	.169 (125) .030	.210 (125) .009	-.049 (129) .292
VB			1.000 (135)	.295 (135) .000	.491 (135) .000	-.306 (131) .000	-.078 (131) .187	-.164 (131) .031	.341 (135) .000
QT				1.000 (135)	.630 (135) .000	-.296 (131) .000	-.425 (131) .000	-.520 (131) .000	.438 (135) .000
AN					1.000 (135)	-.152 (131) .042	-.281 (131) .001	-.346 (131) .000	.335 (135) .000
APC1						1.000 (131)	.144 (131) .050	.198 (131) .133	-.431 (131) .000
APC2							1.000 (131)	.523 (131) .000	-.160 (131) .034
APC3								1.000 (131)	-.170 (131) .026
ZQPR									1.000 (135)

Correlation Coefficient
(Number of Cases)
One-Tailed Significance Level, p-value

B. REGRESSION

SPSSx was used to perform regression analysis on the entire sixth-quarter data set as well as the two major divisions. The intent was twofold. One objective was to determine how much of the variance of a predicted Graduate Quality Point Rating could be explained by the variables of interest. The second objective was to build an equation which could be used by selection boards to predict academic success at the Naval Postgraduate School.

Table 15. CORRELATION TABLE--DIVISION 06

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000 (63)	.732 (60) .000	.080 (63) .268	-.180 (63) .079	-.259 (63) .020	-.020 (63) .438	.172 (63) .088	.066 (63) .305	-.348 (63) .003
T		1.000 (60)	.226 (60) .041	-.137 (60) .148	-.238 (60) .033	-.177 (60) .088	.353 (60) .003	.120 (60) .181	-.170 (60) .097
VB			1.000 (63)	.463 (63) .000	.390 (63) .001	-.103 (63) .210	-.032 (63) .403	.028 (63) .414	.286 (63) .011
QT				1.000 (63)	.699 (63) .000	-.236 (63) .031	-.294 (63) .010	-.231 (63) .034	.594 (63) .000
AN					1.000 (63)	-.070 (63) .294	-.154 (63) .114	-.159 (63) .107	.384 (63) .001
APC1						1.000 (63)	.362 (63) .002	.113 (63) .189	-.263 (63) .019
APC2							1.000 (63)	.198 (63) .060	-.160 (63) .105
APC3								1.000 (63)	-.167 (63) .095
ZQPR									1.000 (63)

Correlation Coefficient
(Number of Cases)
One-Tailed Significance Level, p-value

1. Sixth-Quarter Data

Using the "enter" method, a regression of the Academic Profile Code was run against ZQPR. The intent was to see how well the Academic Profile Code predicted QPR*. Second, a regression equation was formed with just the three Graduate Record Examination scores. In order to see whether combining the two sets of measures would be a better prediction tool, a third equation was developed with all the Academic Profile Code *and* Graduate Record Examination measures as explanatory variables and ZQPR

Table 16. COMBINED CORRELATION TABLE

Coefficients = correlations between ZQPR & the eight variables shown in this table.
*One-tailed significance level = .000

	GRE			APC			Other	
	VB	QT	AN	1	2	3	AGE	T
Sixth-QTR	.311*	.424*	.350*	-.348*	-.108	-.121	-.244*	-.096
Div 05	.341*	.438*	.335*	-.431*	-.160	-.170	-.178	-.049
Div 06	.286	.594*	.384	-.263	-.160	-.167	-.348	-.170

as the dependent variable. Finally, based on the earlier deductions, an equation was formed using VB, QT, AN, APC1 and AGE to explain ZQPR and, hence, QPR*.

The hypothesis for this approach was that R^2 and $\overline{R}^2$ would both increase with successive equations, while the confidence interval around the estimate would decrease. It is understood that R^2 will always increase with the addition of new variables. $\overline{R}^2$, which is R^2 adjusted for degrees of freedom, will increase only if the new variable contributes to the equation.

The results of these equations are summarized in Table 17.

Table 17. REGRESSION RESULTS--SIXTH-QUARTER DATA

Variables	R^2	$\overline{R}^2$	SE
Academic Profile Code APC1, APC2, APC3	.129	.115	.277
Graduate Record Examination VB, QT, AN	.223	.211	.261
APC and GRE Combined APC1, APC2, APC3, VB, QT, AN	.276	.253	.254
Selected Variables APC1, VB, QT, AN, AGE	.289	.270	.252

The Academic Profile Code alone explains only 13 percent of the variance in QPR*. The Graduate Record Examination alone predicts 22 percent. When combined, R^2 rises (as expected) to 27.6 percent. Interesting is that $\overline{R}^2$ increases as well. Finally,

the variables chosen as the best predictors increase R^2 to 28.9 percent and increase $\overline{R}^2$ to 27 percent.

Forecast intervals were developed using Equation (5.1) below.

$$FI = \hat{Y}_{T+1} \pm S_F t_c \tag{5.1}$$

Where FI = the forecast interval
$\hat{Y}_{T-1}$ = the forecast
S_F = the estimated standard error of the forecast
t_c = the critical t value (in this case, 95 percent confidence) [Ref. 20]

For illustration, $\hat{Y}_{T-1} = 3.479$ (the mean ZQPR) for all equations, $t_c = 1.96$ and S_F can be found in Table 17 on page 26 as SE.

Computations reveal an ever-narrowing interval around the mean. See Figure 1 on page 28. These narrowing intervals combined with the good results of the regressions confirm the final set of variables in Table 17 on page 26 as the best predictors of success at Naval Postgraduate School.

The prediction tool for selection boards to use would be the regression equation using VB, QT, AN, APC1 and AGE shown in the order they entered the regression equation:

$$QPR^* = 3.2185 - .0137AGE(\text{in years}) + .0006VB - .0815APC1 + .0007QT + .0001AN \tag{5.2}$$

The results will yield QPR*--a forecast of the officer's Graduate QPR at the Naval Postgraduate School. QPR* will still be a standardized value. If a potential student's curriculum is known, QPR* can be multiplied by the appropriate department factor (Table 5 on page 15) to obtain a sharper estimate for that department. See Appendix A for which curricula belong in the departments.

2. Illustration of Prediction Equation for Admission to NPS

To illustrate the process, assume Lieutenant Junior Grade Grad is being considered for graduate education. He is 27 years old. He graduated from American University with a 3.00 grade point average. His Graduate Record Examination scores are 550 verbal, 600 quantitative and 580 analytical. He is interested in studying in the 681, 847 or 532 curricula.

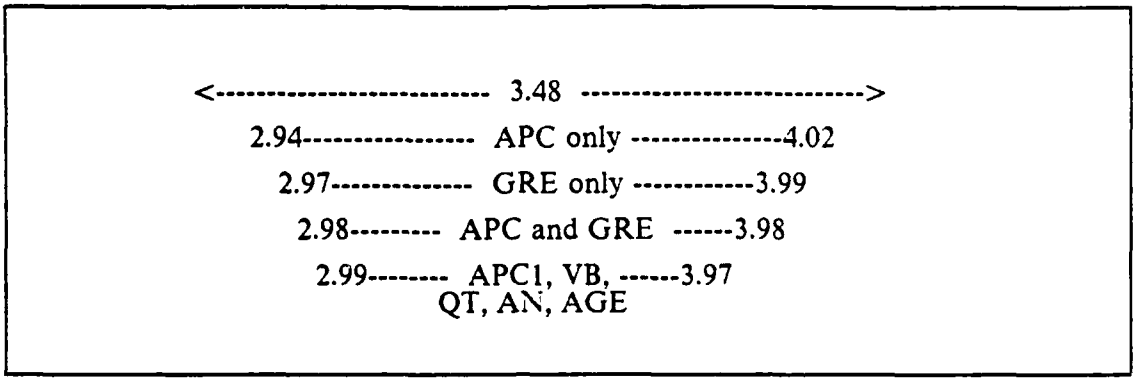

Figure 1. Forecast Intervals--Sixth-Quarter Data

Using Equation (5.2), the selection board would discover a potential Graduate QPR at the Naval Postgraduate School of 3.494. See Equation (5.3).

$$QPR^* = 3.2185 - .0137(27) + .0006(550) - .0815(2) + .0007(600) + .0001(580) = 3.494 \quad (5.3)$$

This predicted Graduate QPR can then be adjusted for the specific curricula Lieutenant Junior Grade Grad is interested in:

for curriculum 681: adjusted QPR* = 3.494(1.067) = 3.73

for curriculum 847: adjusted QPR* = 3.494(.980) = 3.42

for curriculum 531: adjusted QPR* = 3.494(.951) = 3.32

The board could further analyze this officer's potential at the Naval Postgraduate School by putting a forecast interval around each estimate. This would allow the board 95 percent confidence that the officer's Graduate QPR would fall within the range indicated.

For curriculum 681: FI = $3.73 \pm 1.96(.252)$; that is, $3.24 \leftarrow \rightarrow 4.22$

For curriculum 847: FI = $3.42 \pm 1.96(.252)$; that is, $2.93 \leftarrow \rightarrow 3.91$

For curriculum 531: FI = $3.32 \pm 1.96(.252)$; that is, $2.83 \leftarrow \rightarrow 3.81$

Lieutenant Junior Grade Grad may not be as good a risk in the physics curriculum as in national security affairs, or even in manpower, personnel and training analysis.

3. Division Data

Using the same procedures used for the entire data set, regressions were computed for Divisions 05 and 06. The premise is that the two Divisions may have substantially different types of students.

a. Policy and Information Sciences Division (05)

Table 18 shows regression results for Division 05. The results are quite similar, bearing out the choice of APC1, VB, QT, AN and AGE as predictors.

Table 18. REGRESSION RESULTS--DIVISION 05

Variables	R^2	$\bar{R}^2$	SE
APC1, APC2, APC3	.203	.185	.217
VB, QT, AN	.241	.224	.212
APC1, APC2, APC3, VB, QT, AN	.309	.276	.204
APC1, VB, QT, AN, AGE	.312	.285	.203

Slightly narrower forecast intervals are evident in Figure 2. These intervals are also built around the mean ZQPR of 3.48.

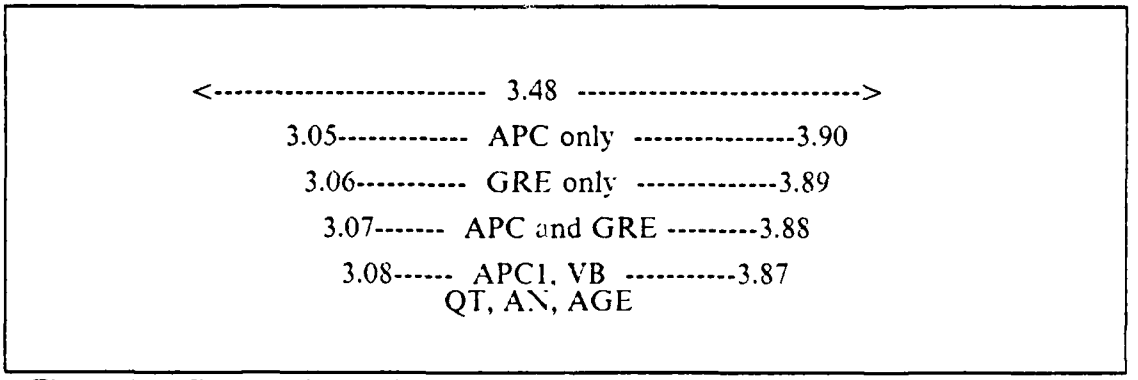

Figure 2. Forecast Intervals--Division 05

Equation (5.4) is the prediction tool for this submodel. It could be used if the selection board were assured an officer would be interested in only Policy and Information Sciences curricula.

$$QPR^* = 3.1520 - .0052AGE(in\ years) + .0004VB - .0814APC1 + .0007QT + .0002AN \qquad (5.4)$$

b. Sciences and Engineering Division (06)

Table 19 on page 30 contains regression results for Division 06. The results for this subgroup are considerably stronge R^2 = .4440 as compared to .3123 for Division 05.

Table 19. REGRESSION RESULTS--DIVISION 06

Variables	R^2	$\bar{R}^2$	SE
APC1, APC2, APC3	.091	.044	.376
VB, QT, AN	.355	.322	.317
APC1, APC2, APC3, VB, QT, AN	.374	.307	.320
APC1, VB, QT, AN, AGE	.444	.395	.299

Forecast intervals for Division 06 are considerably wider than either the overall data or Division 05 data. See Figure 3. The wider intervals are due to larger standard errors in this subgroup. One possible explanation is the smaller number of cases in this sample combined with the different type of students. These intervals, again are built around the mean ZQPR of 3.48.

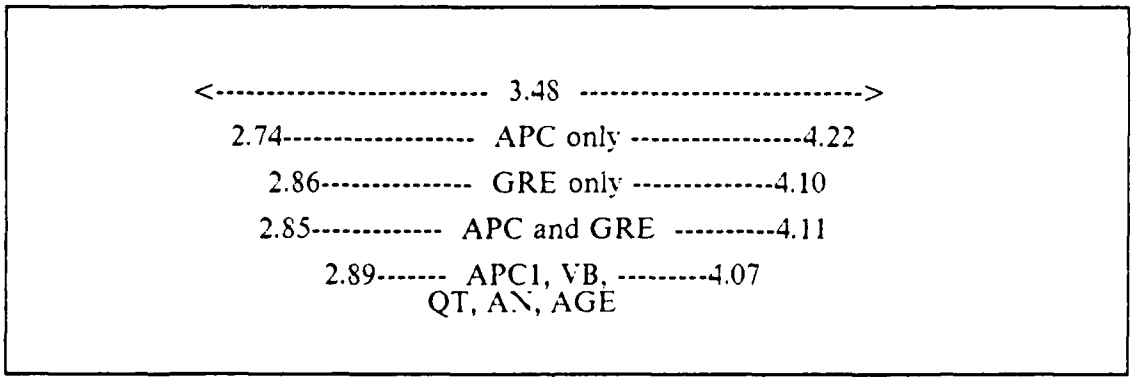

Figure 3. Forecast Intervals--Division 06

Equation (5.5) is the prediction tool for this submodel. It could be used if the selection board were assured an officer would be interested in only Sciences and Engineering curricula.

$$QPR^* = 2.7122 - .0308AGE(in\ years) - .0693APC1 + .0004VB - .0004AN + .0028QT \quad (5.5)$$

c. Conclusion

The Division regressions confirm the choice of variables for predicting Graduate QPR, namely, VB, QT, AN, APC1 and AGE. R^2 in the Division computations is stronger in both cases than the overall regression. The results are strongest for Division 06.

Using the individual Division prediction equations would be limiting to a selection board since the board would have to know exactly which curriculum an officer would be assigned to. A better tool would be Equation (5.2) which would allow a selection board to predict Graduate QPR for any officer. The department factor could always be applied for individual curricula--perhaps during the assignment process.

$$QPR^* = 3.2185 - .0137AGE(\text{in years}) + .0006VB - .0815APC1 + .0007QT + .0001AN \quad (5.2)$$

Where QPR*= the predicted Graduate QPR
AGE = the officer's age
VB = the Graduate Record Examination Verbal measure
APC1= the Undergraduate QPR
QT = the Graduate Record Examination Quantitative measure
AN = the Graduate Record Examination Analytical measure

C. DEPARTMENTS

One of the original research questions was "Is there a difference in predictive value for different curricula?" In narrowing the specification of the data set, N became very small for individual curricula: range = 0 to 23. These small sample sizes would render computed statistics unreliable.

Correlation and regression computations were made for the two departments in which N was greater than or equal to 25. Results are outlined in Appendix B.

D. HOW DOES NAVAL POSTGRADUATE SCHOOL COMPARE?

Educational Testing Service provides a means whereby an institution's students' scores on the Graduate Record Examination may be compared (in percentile fashion) to earlier test-takers. Table 20 on page 33 displays percentile ranks and scaled scores for General Test examinees between 1981 and 1985. Added in the right four sets of columns are mean scores for all Naval Postgraduate School students who have participated in the study so far, sixth-quarter students and the 05 and 06 Division students.

This table shows Naval Postgraduate School students well above the Educational Testing Service mean--particularly in the quantitative measure.

Table 20. GENERAL TEST INTERPRETIVE DATA

Based on performance of General Test examinees between 1 Oct 81 & 30 Sep 84

Percent of Examinees Scoring Lower Than Selected Scaled Scores

Scaled Scores	VB	QT	AN	All NPS VB	All NPS QT	All NPS AN	6th-Qtr VB	6th-Qtr QT	6th-Qtr AN	Div 05 VB	Div 05 QT	Div 05 AN	Div 06 VB	Div 06 QT	Div 06 AN
800		99	99												
780	99	98	98												
760	99	95	97												
740	98	92	96												
720	96	89	94												
700	95	85	92												
680	93	81	90											677	
660	91	77	86												
640	88	73	83		632			627							
620	85	67	79								604				
600	81	64	76												593
						585			588			585			
580	78	58	70												
560	73	53	65							553					
				548			545								
540	68	48	60										528		
520	63	43	54												
500	57	38	48												
480	52	32	37												
460	46	28	37												
440	40	24	30												
420	35	20	26												
400	29	17	21												
380	25	13	17												
360	20	11	13												
340	16	8	9												
320	12	6	7												
300	10	5	4												
280	7	3	3												
260	4	2	2												
240	3	1	1												
220	1	1													
Mean	472	539	505												
	N = 785,276			N = 780			N = 198			N = 135			N = 63		

Source: Educational Testing Service *Guide* [Ref. 16: p. 17] & research data set means

VI. LIMITATIONS

The results shown from this study may be influenced to an undetermined degree by a number of factors.

Most of the students taking the test during this three-year study have been away from school for a number of years. Does that affect their Graduate Record Examination scores? The exam is administered *after* arrival at the school. Does that affect students' motivation, and subsequently, their performance? If motivation is high, would they study before taking the test? Would studying improve the scores?

A. ADMINISTRATION OF THE GRADUATE RECORD EXAMINATION

One of the concerns of the conduct of this study is the timing of the administration of the Graduate Record Examination. Most examinees take the test in their senior year of college or shortly thereafter. Their purpose in taking the exam is to submit scores to graduate school as part of the admissions procedure. Their motivation is fairly well-defined: "The better I do on this test, the better my chances of getting into the school of my choice."

During this study, the Graduate Record Examination is administered to incoming classes of students in their first few weeks of school. This is a time when students are in the process of readjusting to academic life and can be very close to the time of the first midterm exams. Other than a personal pride and motivation to always do the best you can, there is no true incentive for doing well on the Graduate Record Examination. These test-takers have been accepted and are enrolled; the exam results have no bearing on their academic or professional future.

There are two conflicting views on this potential problem. In his response to the Graduate Education Review Board tasking, the Superintendent of the Naval Postgraduate School indicated that the "GRE was given to students at the Postgraduate School about twenty years ago, but only after they arrived and consequently served no use in the selection process." [Ref. 16] Barr and Howard acknowledged that the data being analyzed are of students who have already been selected based on Academic Profile Code and undergraduate and professional performance. They believe, however, "that this does not pose a serious problem." [Ref. 12]

Not mentioned in either case is the lack of some sort of control group. As the examinees in this study are all a specially selected group, there is no way to compare

them to the "universe" containing *all* students. The selection process does not know whether Graduate Record Examination scores of those selected for the school are significantly higher than the scores of those not selected for graduate education.

The author conducted an informal ad hoc survey of a number of classmates to determine whether they knew why they were taking the exam and what sort of effort they made in taking the test. Most of the classmates admitted a vague understanding of why they were taking the Graduate Record Examination. Many, however, indicated that they had not exerted as much effort as they would have had the exam been a requirement for admission. None of the students had made an effort to study or otherwise prepare for the exam.

B. OLDER STUDENTS

Students selected for the Naval Postgraduate School are generally lieutenants or lieutenant commanders. This means they have been in the Navy at least four years and are generally in their mid- to late twenties. As revealed earlier, the test-takers in the current study average 31 years of age and had earned their undergraduate degree an average of 7.6 years ago.

Several researchers have studied the effect on Graduate Record Examination scores of being an "older student." Hartle, Baratz and Clark looked at test-takers who were 30 years of age or older or who had graduated with an undergraduate degree eight or more years ago. They found that the sample had a greater number of women and minorities than expected. Their hypothesis was that these categories of people, for a number of reasons, do not go directly to graduate school from their undergraduate programs. They also found that choice of studies favored education and the humanities and social sciences. Their bottom line was that, on average, older students' Graduate Record Examination scores were lower than younger students' scores--particularly in the quantitative portion of the exam. [Ref. 21]

Clark discussed the subject further in 1984 and found that average verbal scores were about the same for both types of students. Quantitative scores, however, were generally lower. She further reported on a study conducted by Hartnett and Oltman in 1983. They reported that overall, the verbal scores tend to be higher for "older" women and about the same for "older" men. The quantitative scores are usually lower for both men and women. [Ref. 22]

It remains for a further study to determine whether the scores--especially quantitative scores--should perhaps be weighted in some fashion to account for the "older"

students or whether the Graduate Record Examination should simply be administered at an earlier time in an officer's career.

C. PREPARATORY STUDY

Swinton and Powers have studied the effects of coaching and preparatory study on the Graduate Record Examination for about six years. Their latest effort in 1985 concluded that any coaching or preparatory study beyond average student preparation for the Graduate Record Examination would "probably not result in higher test scores." [Ref. 23: p. 23] This conclusion applied to all three measures of the Graduate Record Examination. They assume *some* test preparation (i.e., reading the *GRE Information Bulletin*) by the average student. Not only have Naval Postgraduate School test-takers not received the *Bulletin* prior to the exam, they have no real incentive to undertake even limited preparation.

VII. CONCLUSION

A. SUMMARY

The data reveal that the Graduate Record Examination is a much stronger predictor of graduate success than the Academic Profile Code. Even stronger is the Graduate Record Examination plus APC1 and AGE. Although R^2 is not exceedingly large, this can be explained by the variety of other variables which can also be considered when making graduate selections. These are variables which would be very difficult to quantify: professional performance, promotability, military career path, variances among undergraduate institution grading policies, personality factors, family status and IQ are but a few.

B. RECOMMENDATIONS

Based on the analysis conducted in this thesis, Navy should consider using the Graduate Record Examination in conjunction with undergraduate grade point averages and the age of the officer. These measures should supplement professional and military considerations in the selection process. Rather than trying to establish a cutoff score for the Graduate Record Examination elements, selection boards should use Equation (5.2) to determine potential academic success at the Naval Postgraduate School.

$$QPR^* = 3.2185 - .0137AGE(in\ years) + .0006VB - .0815APC1 + .0007QT + .0001AN \quad (5.2)$$

Where QPR*= the predicted Graduate QPR
AGE = the officer's age
VB = the Graduate Record Examination Verbal measure
APC1= the Undergraduate QPR
QT = the Graduate Record Examination Quantitative measure
AN = the Graduate Record Examination Analytical measure

This equation is recommended to simplify computations for the selection boards. The overall equation will allow boards to compute one equation for all candidates, regardless of choice of curriculum. The department factor should be applied later, during the assignment process, to better place students in appropriate curricula.

C. FURTHER RESEARCH

Further research on this data should be conducted when the study is officially completed. This will increase the number of cases for observation and undoubtedly enrich the results.

A cost benefit analysis should be conducted to determine which of the measures is more economical. This should include the current Academic Profile Code procedures, administration of the Graduate Record Examination (or reimbursement for exams administered at non-Navy facilities) and record maintenance costs.

The effect of the time and place of administering the exam is an important issue which must be addressed. The exam should be administered early in an officer's career in order to be available and current during the graduate education selection process.

Further research needs to be made within the 15 departments. There is some evidence, even with this small data set, that predictions will vary across curricula. When a more reliable set of equations can be formulated, they should be used to select students and to place them into appropriate curricula.

If the Graduate Record Examination is administered close to the officer's commissioning, there is still a potential problem of "older" students. Officer Candidate School and Officer Indoctrination School students can be older at commissioning than Reserve Officer Training Corps (ROTC) or Academy graduates. To make scores more equivalent, a weighting factor could be developed for the older examinees.

In any case, the Graduate Record Examination should be a *much* better predictor than the Academic Profile Code alone.

APPENDIX A. NPS CURRICULA

05 Policy and Information Sciences Division

52 Computer Science Department

367 Computer Systems Management

368 Computer Science

53 Mathematics Department

380 Advanced Science

54 Administrative Sciences Department

813 Transportation Logistics Management

814 Transportation Management

815 Acquisition and Contract Management

819 Systems Inventory Management

827 Material Logistics Support Management

837 Financial Management

847 Manpower, Personnel and Training Analysis

620 Telecommunications Systems Management

55 Operations Research Department

360 Operations Analysis

361 Operational Logistics

56 National Security Affairs Department

681 Middle East, Africa, South Asia

682 Far East, Southeast Asia, Pacific

683 Europe, USSR

684 International Organizations and Negotiations

685 Western Hemisphere

686 Strategic Planning - General

687 Strategic Planning - Nuclear

825 Intelligence

06 Sciences and Engineering Division

61 Physics Department

530 Weapons Systems Engineering

531 Weapons Systems Science (Physics)

532 Nuclear Physics (Weapons and Effects)

535 Underwater Acoustics

62 Electrical and Computer Engineering Department

590 Electronic Systems Engineering

600 Communications Engineering

63 Meteorology Department

372 Meteorology

373 Air-Ocean Science

67 Aeronautics Department

610 Aeronautical Engineering

611 Aeronautical Engineering - Avionics

68 Oceanography Department

374 Operational Oceanography

440 Oceanography

441 Hydrographic Sciences

69 Mechanical Engineering Department

570 Naval (Mechanical) Engineering

71 Antisubmarine Warfare Academic Group

525 Antisubmarine Warfare Systems

72 Electronic Warfare Academic Group

595 Electronic Warfare Systems Engineering

73 Space Systems Academic Group

366 Space Systems Operations

591 Space Systems Engineering

74 Command, Control and Communications Academic Group

365 Joint Command, Control and Communications

APPENDIX B. DEPARTMENT STATISTICS

52 Computer Science (N = 28)

Table 21. DESCRIPTIVE STATISTICS--DEPARTMENT 52

Variable	Mean	Minimum	Maximum	Standard Deviation
AGE	31.43	26	39	3.65
T	8.11	4	15	2.99
APC1	2.12	0	4	.950
APC2	2.54	0	5	.990
APC3	3.65	0	5	1.88
VB	536.43	430	670	75.44
QT	596.07	440	800	90.81
AN	578.93	440	770	78.47
ZQPR	3.43	2.86	3.89	.253

Table 22. REGRESSION RESULTS--DEPARTMENT 52

Variables	R^2	$\bar{R}^2$	SE
APC1, VB, QT, AN, AGE	.361	.201	.225

Forecast Interval: $3.479 \pm 1.96(.2254)$; that is, $3.04 \leftarrow\rightarrow 3.92$

$$QPR^* = 3.2185 - .0137AGE(\textit{in years}) + .0006VB - .0815APC1 + .0007QT + .0001AN$$

Table 23. CORRELATION TABLE--DEPARTMENT 52

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000	.788	.400	-.236	-.167	.125	.323	.343	-.260
	(28)	(27)	(28)	(28)	(28)	(26)	(26)	(26)	(28)
		.000	.017	.113	.198	.271	.054	.043	.091
T		1.000	.341	-.106	-.195	.073	.339	.308	-.061
		(27)	(27)	(27)	(27)	(25)	(25)	(25)	(27)
			.055	.299	.164	.364	.049	.067	.382
VB			1.000	.295	.303	-.160	-.019	.051	.088
			(28)	(28)	(28)	(26)	(26)	(26)	(28)
				.064	.058	.217	.463	.403	.328
QT				1.000	.697	-.417	-.482	-.689	.481
				(28)	(28)	(26)	(26)	(26)	(28)
					.000	.017	.006	.000	.005
AN					1.000	-.132	-.255	-.279	.134
					(28)	(26)	(26)	(26)	(28)
						.261	.104	.084	.249
APC1						1.000	.611	.472	-.453
						(26)	(26)	(26)	(26)
							.000	.008	.010
APC2							1.000	.601	-.562
							(26)	(26)	(26)
								.001	.001
APC3								1.000	-.403
								(26)	(26)
									.021
ZQPR									1.000
									(28)

Correlation Coefficient
(Number of Cases)
One-Tailed Significance Level, p-value

53 Mathematics (N = 0)

No statistics computed.

54 Administrative Sciences (N = 66)

Table 24. DESCRIPTIVE STATISTICS--DEPARTMENT 54

Variable	Mean	Minimum	Maximum	Standard Deviation
AGE	31.58	25	37	3.16
T	8.06	3	15	3.00
APC1	1.83	0	4	.883
APC2	3.00	0	6	1.13
APC3	4.27	0	5	1.19
VB	550.15	300	710	92.89
QT	587.58	370	750	89.31
AN	575.91	340	800	96.36
ZQPR	3.53	2.96	3.97	.239

Table 25. REGRESSION RESULTS--DEPARTMENT 54

Variables	R^2	$\bar{R}^2$	SE
APC1, VB, QT, AN, AGE	.353	.297	.201

Forecast Interval: $3.479 \pm 1.96(.2007)$; that is, $3.09 \longleftrightarrow 3.87$

$$QPR^* = 2.8066 + .0010AGE(\text{in years}) - .0070APC1 + .0003VB + .0007QT + .0004AN$$

Table 26. CORRELATION TABLE--DEPARTMENT 54

	AGE	T	VB	QT	AN	APC1	APC2	APC3	ZQPR
AGE	1.000	.703	-.116	-.261	-.291	.010	.336	.215	-.128
	(66)	(65)	(66)	(66)	(66)	(64)	(64)	(64)	(66)
		.000	.177	.017	.009	.467	.003	.044	.153
T		1.000	.110	-.067	-.099	-.087	.198	.057	-.017
		(65)	(65)	(65)	(65)	(63)	(63)	(63)	(65)
			.192	.298	.217	.248	.060	.328	.446
VB			1.000	.447	.536	-.226	-.082	-.244	.400
			(66)	(66)	(66)	(64)	(64)	(64)	(66)
				.000	.000	.037	.259	.026	.000
QT				1.000	.662	-.214	-.246	-.334	.499
				(66)	(66)	(64)	(64)	(64)	(66)
					.000	.044	.025	.003	.000
AN					1.000	-.039	-.216	-.278	.439
					(66)	(64)	(64)	(64)	(66)
						.380	.044	.013	.000
APC1						1.000	-.016	-.168	-.374
						(64)	(64)	(64)	(64)
							.450	.092	.001
APC2							1.000	.392	-.141
							(64)	(64)	(64)
								.001	.134
APC3								1.000	-.049
								(64)	(64)
									.350
ZQPR									1.000
									(66)

Correlation Coefficient
(Number of Cases)
One-Tailed Significance Level, p-value

55 Operations Research (N = 13)

No statistics computed.

56 National Security Affairs (N = 18)

No statistics computed.

61 Physics (N = 12)

No statistics computed.

62 Electrical and Computer Engineering (N = 16)

No statistics computed.

63 Meteorology (N = 4)

No statistics computed.

67 Aeronautics (N = 5)

No statistics computed.

68 Oceanography

No statistics computed.

69 Mechanical Engineering (N = 13)

No statistics computed.

71 Antisubmarine Warfare (N = 8)

No statistics computed.

72 Electronic Warfare (N = 2)

No statistics computed.

73 Space Systems (N = 12)

No statistics computed.

74 Command, Control and Communications (N = 1)

No statistics computed

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